Section 4: Nitrogen Inert Atmosphere Reflow

Reflow soldering in a nitrogen atmosphere is a common process consideration in SMT assembly. The issue is not the ability to reflow in nitrogen, but rather the ability to reflow in the absence of oxygen. Heating solder in the presence of oxygen will create oxides, which are generally non-solderable surfaces.

Oxidation is effected by temperature, surface area, flux content, metal content and condition, and oxygen levels around the solder joint. Let’s take a look at the variables that effect oxidation and discuss their impact.

Temperature
Oxidation is directly related to temperature. Higher temperatures mean faster rates of oxidation. Thus, reflowing at the lowest possible temperature reduces the amount of oxidation created during the reflow process. Convection technology helps (as compared with IR) in that heating uniformity is better and thus the maximum temperature on the product may be reduced.

Surface Area
More surface area means more area available for oxidation. As the pitch between leads becomes finer and finer, the tin/lead solder particles in the paste must become smaller to obtain good paste print definition.

As solder particles become smaller, the ratio of surface area to volume of the particles increases. This can be shown by:

\[
\text{Ratio} = \frac{\pi \cdot D^2}{\frac{1}{6} \cdot \pi \cdot D^3}
\]

\[
\text{Ratio} = 6 / D
\]

Where: D = Particle Diameter

Thus, as solder particle size decreases, the surface area to volume ratio increases.

With more available surface area in the solder paste, there is a greater tendency towards oxidation.

Flux Content
In the early days of reflow soldering, solder paste contained aggressive enough fluxes to easily remove oxides. Often CFC solvent cleaning was used to remove any remaining residue from the board.

As CFC’s were phased out, so has the most effective means of cleaning rosin based
pastes from the board. Today, water-soluble Organic Acid (OA) fluxes are used, and the cleaning process has changed to a water wash system.

Many companies have eliminated cleaning completely and have gone to a no-clean process. The term “no-clean” is misleading, as it only implies that water wash cleaning has been eliminated. Some people have changed nothing in their process, except they no longer clean the product.

This is satisfactory providing the desired functional life of the end product is not high, which may be the case with many consumer products. After several years of operation and thermal cycling, the residues that were left on the board can cause short circuits, or simply corrode the circuit away. If the desired long term reliability of the product is important, then this is not satisfactory.

The amount of residues left on the product will determine its long-term reliability. The bottom line is that higher residue pastes are more solderable in air. Although the line is moving, the low residue pastes (<2.5%) may not be air reflowable. Thus, the weaker the flux, the greater the chance for oxidation.

No-clean soldering requires tight control of the process. All of the components and boards must be highly solderable. Since the board is not washed to remove any solder balls from the product, the reflow process must prevent solder ball build up. Solder balls can create short circuits on the product if they are not removed.

**Metal Content and Condition**

Some metals are more solderable than others. It is much easier to solder to a board that has a tin/lead coating on it as compared to a bare copper board. The condition of the metal to be soldered also has an impact on solderability. If boards have been sitting on the shelf unprotected for many months, a coating of oxidation will be over the metal. This will make the reflow job more difficult. Double sided reflow can also be more difficult when reflowing the second side. The second side has already been heated once, which may have created surface oxidation.

<table>
<thead>
<tr>
<th>Oxidation Variable</th>
<th>Variable Trend</th>
<th>Reflow Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Hotter</td>
<td>Worse</td>
</tr>
<tr>
<td>Air Velocity</td>
<td>Higher</td>
<td>Worse</td>
</tr>
<tr>
<td>Oxygen Content</td>
<td>Lower</td>
<td>Better</td>
</tr>
<tr>
<td>Exposed Area</td>
<td>More</td>
<td>Worse</td>
</tr>
<tr>
<td>Metal Content</td>
<td>Non-Tinned</td>
<td>Worse</td>
</tr>
<tr>
<td>Flux Activity</td>
<td>Less</td>
<td>Worse</td>
</tr>
</tbody>
</table>

*Figure 4-2. Variables that effect oxidation.*
Oxygen Levels
None of the variables in Figure 4-2 by itself is enough reason to use a pure nitrogen environment in the reflow process. However, if several of these combine (such as a fine pitch, low residue paste), then an atmosphere void of oxygen may be required in order to accomplish satisfactory reflow.

This requires an oven that can run at low levels of oxygen. The oxygen level is measured in parts per million, or ppm. Air atmosphere is 21% oxygen, which is 210,000 ppm. Most ovens have the option to operate at less than 100 ppm oxygen environment.

The purity level required (if any) is dictated by the process variables discussed previously. There is no magic number of purity that is required for a given board.

Solder pastes are continuously changing in the quest towards air reflowable pastes that leave no residue. While the perfect paste does not exist, solder pastes have continually improved to the point where one should experimentally determine whether nitrogen has any significant impact on your process. If it does not, do not use nitrogen!